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Specificity of wide QRS complex tachycardia criteria and algorithms in patients with ventricular preexcitation

Marek Jastrzębski MD, PhD[1] | Paweł Moskal MD[1] | Piotr Kukla MD, PhD[2] | Kamil Fijorek PhD[3] | Roksana Kisiel MD[1] | Danuta Czarnecka MD, PhD[1]

[1]First Department of Cardiology, Interventional Electrocardiology and Hypertension, Medical College, Jagiellonian University, Cracow, Poland

[2]Department of Cardiology, H. Klimontowicz Specialistic Hospital, Gorlice, Poland

[3]Department of Statistics, Cracow University of Economics, Cracow, Poland

Correspondence
Marek Jastrzębski, MD, PhD, First Department of Cardiology, Interventional Electrocardiology and Hypertension, University Hospital, Cracow, Poland.
Email: mcjastrz@cyf-kr.edu.pl

Background: Despite substantial progress in the field of differentiation between ventricular tachycardia (VT) and supraventricular tachycardia (SVT) with wide QRS complexes, differentiation between VT and preexcited SVT remains largely unresolved due to significant overlap in QRS morphology. Our aim was to assess the specificities of various single ECG criteria and sets of criteria (Brugada algorithm, aVR algorithm, Steurer algorithm, and the VT score) for diagnosis of VT in a sizable cohort of patients with preexcitation.

Methods: We performed a retrospective study of consecutive accessory pathway ablation procedures to identify preexcited tachycardias. Among 670 accessory pathway ablation procedures, 329 cases with good quality ECG with either bona fide preexcited SVT (n = 30) or a surrogate preexcited SVT (fast paced atrial rhythm with full preexcitation, n = 299) were identified. ECGs were analyzed with the use of wide QRS complex algorithms/criteria to determine specificities of these methods.

Results: The Steurer algorithm and VT score (≥3 points), with specificities of 97.6% and 96.1%, respectively, were significantly (p < .01) more specific for the diagnosis of VT than Brugada algorithm, aVR algorithm, and Pava criterion with specificities of 31%, 11.6%, and 57.1%, respectively. The first step of the Brugada algorithm and the first step of the aVR algorithm had also high specificities of 93.3% and 96.0%, respectively.

Conclusion: There are sufficient electrocardiographical differences between VT and preexcited SVT to allow electrocardiographic differentiation. VT score, Steurer algorithm, and some single criteria do not overdiagnose VT in patients with preexcitation.

KEYWORDS

preexcitation, ventricular tachycardia, VT score, wide QRS complex tachycardia, WPW syndrome

1 | INTRODUCTION

Several ECG-based methods for wide QRS complex tachycardia (WCT) diagnosis were developed over the last 50 years, leading to substantial progress in the field of differentiation between ventricular tachycardia (VT) and supraventricular tachycardia (SVT) with wide QRS complexes (Brugada, Brugada, Mont, Smeets, & Andries, 1991; Griffith, Garratt, Mounsey, & Camm, 1994; Jastrzebski, Kukla, Czarnecka, & Kawecka-Jaszcz, 2012a; Jastrzebski et al., 2016; Kindwall, Brown, & Josephson, 1988; Lau et al., 2000; Marriott, 1970; Sandler & Marriott, 1965; Swanick, LaCamera, & Marriott, 1972; Vereckei, Duray, Szenasi, Altemose, & Miller, 2008). However, most of the available criteria/methods seem to be capable only of differentiation between VT and SVT with aberrant conduction, while differentiation between VT and preexcited SVT remains largely unresolved. Most of the published studies either excluded patients with preexcitation, or did not report if such patients were included, or even grouped preexcited SVT patients with VT patients (Jastrzebski et al., 2012a; Vereckei & Miller, 2012). Preexcitation unquestionably warrants

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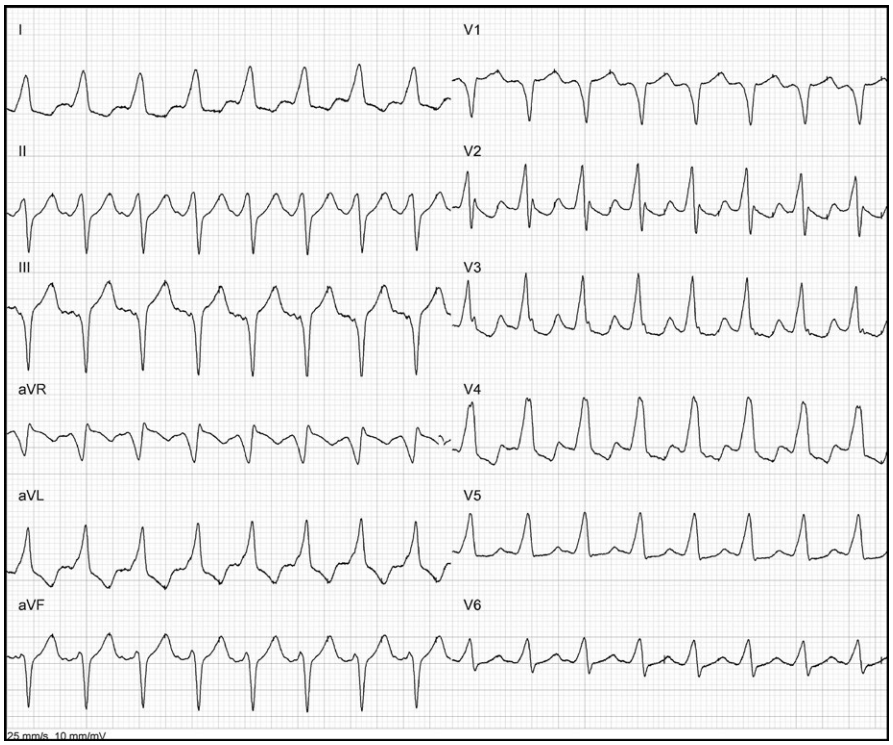

FIGURE 1 Twelve-lead ECG showing full preexcitation via mid-septal accessory pathway during atrial pacing. A slow initial ventricular depolarization is present in both limb and precordial leads. The RS interval in V_6 is >100 ms, the V_i/V_t in aVR is <1, and the RWPT in lead II is >50 ms—these results in misdiagnosis of this preexcited SVT as a VT by the Brugada algorithm, the aVR algorithm, and the Pava criterion. In contrast, the VT score of 1 point does not make the diagnosis of VT. Paper speed is 25 mm/s

differentiation from VT as there is a clear difference between, for example, a preexcited atrial flutter and a ventricular tachycardia in terms of pathophysiology and management (Jastrzebski & Kukla, 2012). Some believe that neither traditional nor novel QRS morphologic criteria are capable of differentiation between preexcited SVT and VT, as in both cases, depolarization of the ventricles begins in the working myocardium, outside of the His-Purkinje system, giving rise to an initially slow ventricular depolarization—a phenomenon from which multiple ECG criteria for differentiation are derived (Figure 1) (Vereckei & Miller, 2012; Vereckei et al., 2008). However, there is little published data to either support or refute this view. Our previous studies suggest that some methods might be better at differentiating preexcited SVT from VT (Jastrzebski et al., 2012a; Jastrzebski et al., 2016). However, this might be difficult to prove in studies involving general WCT population as preexcited SVT generally constitute only a small percentage of WCT cases.

2 | AIM

To assess the specificity of a wide spectrum of ECG criteria and sets of criteria (Brugada algorithm, aVR algorithm, Steurer algorithm, and the VT score) for diagnosis of ventricular tachycardia in a sizable cohort of patients with overt preexcitation.

3 | METHODS

3.1 | Studied cohort

All consecutive ablation procedures in patients diagnosed with an overt accessory pathway from years 2002 to 2016 were retrospectively analyzed to obtain a good quality 12-lead ECGs with either bona fide preexcited SVT (antidromic atrioventricular tachycardia, preexcited atrial flutter, or other preexcited regular supraventricular tachycardia) or with maximal obtainable preexcitation induced by incremental atrial pacing (just before block in accessory pathway was observed), considered a good surrogate for preexcited SVT.

3.2 | Analysis of ECGs

All preexcited electrocardiograms recorded with standard amplification and at a paper speed of 25 mm/s were analyzed by two observers (a cardiology specialist and a cardiology resident) and in a case of conflicting results, by a third doctor (an electrophysiologist) who made the final verdict in these cases.

The following QRS morphologic criteria/algorithms/methods were analyzed:

1. Brugada algorithm criteria (lack of an RS complex in leads V_1–V_6; presence of an RS interval > 100 ms; atrioventricular (AV) dissociation, presence of VT morphologic criteria in both V_1 and V_6) (Brugada et al., 1991).
2. Presence of aVR algorithm criteria (monophasic R in aVR; initial r/q > 40 ms in aVR; notched S in aVR, initial to terminal QRS velocity ratio (V_i/V_t) ≤ 1 (Vereckei et al., 2008).
3. The R-wave peak time (RWPT) criterion. The RWPT represents the interval from the beginning of the QRS to the first visible change in direction of the initial polarity, from ascending to descending or vice versa, that is, to R-wave peak or S-wave nadir or any notch on the descending limb of the S wave or the ascending limb of the R; RWPT ≥ 50 ms is diagnostic for VT (Pava et al., 2010).

4. Steurer algorithm criteria (predominantly negative QRS complexes from V_4 to V_6, qR complex in any of V_2–V_6, AV dissociation) (Steurer et al., 1994).
5. The ventricular tachycardia score method criteria as defined and described in detail recently (Jastrzębski, Kukla, & Czarnecka, 2017; Jastrzebski et al., 2016). Briefly, the VT score is a novel approach to VT diagnosis which provides a graded response from 0 to 8 points, rather than a "yes or no" type of answer from WCT algorithms. This allows the physician to know how much he can trust the obtained diagnosis of VT. With each point, the probability of VT diagnosis increases and a firm diagnosis of VT can be made when 3 or more VT score points are obtained. Following QRS, morphologic criteria were assigned one point: initial R wave in V_1, initial r > 40 ms in V_1 or V_2, notched S in V_1, initial R wave in aVR, lead II RWPT ≥ 50 ms, and lack of RS complex in leads V_1–V_6. AV dissociation (including fusion/capture beats and partial dissociation) was assigned two points.

3.3 | Statistics

Each analysis method was assessed in terms of the presence of a particular criterion during preexcited SVT, that is, the amount of false-positive results, as there were no true VT included, thus leading to the calculation of specificity of a criterion/method for VT diagnosis. Calculated specificity values were compared using McNemar test (Fijorek, Fijorek, Wisniowska, & Polak, 2011). For all analyses, a p value < .05 was considered to indicate a significant difference. Statistical analyses were performed using "R"—a language and environment for statistical computing (http://www.R-project.org).

4 | RESULTS

We analyzed 670 consecutive accessory pathway ablation procedures. Among these, 329 cases with good quality ECG with either bona fide preexcited SVT (n = 30) or a surrogate preexcited SVT (n = 299) were identified. Remaining patients had either concealed accessory pathway or poor/intermittent antegrade accessory pathway conduction. All antiarrhythmic drugs were stopped at least 3 days before the study. The studied group (n = 329) has basic clinical characteristics: males, 57%; average age, 34 ± 12 years; organic heart disease (coronary heart disease, heart failure, cardiomyopathy, etc.) present in 4.8% of cases.

We found that several criteria were very specific for VT diagnosis: no RS complex in V_1–V_6, dominant R in aVR, AV dissociation, VT score ≥ 3, VT score ≥ 4, and S notch in aVR. Negative QRS V_4–V_6 and QR in any of V_2–V_6 were in seen in only 6.4%, 4%, 0%, 3.9%, 0%, 5.5%, 0.3%, and 1.5% of preexcited tachycardias, respectively. This resulted in good overall specificity of two methods—the VT score and the Steurer algorithm, which were significantly more specific for VT diagnosis than other methods (p < .0001). On the other hand, several differentiation criteria/algorithms, both classic and novel, were found to be unsuitable for differentiation of VT from preexcited SVT due to very low specificity, and this included aVR algorithm, aVR V_i/V_t criterion, VT score ≥ 1, and Brugada algorithm. Detailed data concerning specificities of all assessed criteria and whole algorithms are presented in Table 1.

TABLE 1 Various criteria and methods: specificity for ventricular tachycardia diagnosis in patients with preexcited tachycardias

Criterion/Method	SP (%)	p^*
VT score criteria	-	-
R in V_1	61.4	.0000
r > 40 ms in V_1/V_2	82.7	.0000
S notch in V_1	88.5	.0003
No RS in V_1–V_6	93.3	.1237
R in aVR	96.0	.7893
AV dissociation	100	.0009
Lead II RWPT ≥ 50 ms	57.1	.0000
VT score ≥ 1	22.2	.0000
VT score ≥ 2	60.8	.0000
VT score ≥ 3	96.1	-
VT score ≥ 4	100	.0009
aVR algorithm criteria[a]		
S notch in aVR	94.5	.4725
r/q > 40 ms in aVR	89.1	.0017
aVR Vi/Vt	14.9	.0000
aVR algorithm	11.5	.0000
Brugada algorithm criteria[a]		
V_1–V_6 RS > 100 ms	46.8	.0000
4th step (V_1 + V_6) criteria	74.8	.0000
Brugada algorithm	31.0	.0000
Steurer algorithm criteria		
Negative QRS V_4–V_6	99.7	.0033
QR in any of V_2–V_6	98.5	.0990
Steurer algorithm	97.6	.3827

[*] p calculated versus VT score ≥3.
[a] only criteria not already included in the VT score are listed, however, calculation of specificity of the whole algorithms included all pertinent criteria as explained in the Methods.

Distribution of VT scores in the studied cohort with preexcited SVT was significantly (p < .001) different from that observed previously in patients with VT (Table 2) (Jastrzebski et al., 2016).

5 | DISCUSSION

This is the first study that assesses specificities of wide selection of criteria and algorithms for WCT diagnosis with regard to their ability to differentiate between preexcited SVT and VT. The major finding of the study is that some of these methods (the VT score, the Steurer algorithm, and selected criteria from other algorithms) are capable of high specificity for VT diagnosis in this setting.

TABLE 2 Distribution of VT scores in the currently studied cohort of preexcited SVT and in a real-life VT cohort

	VT score					
WCT type	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	≥5 (%)
VT[a]	6.2	16.6	19.9	24.8	18.9	13.7
Preexcited SVT	22.2	38.6	35.3	3.9	0	0

$p < .001$.
[a]VT distribution data from Jastrzebski et al. (2016).

Despite valid theoretical considerations that a preexcited SVT and a VT might lead to identical depolarization of the ventricles (i.e., depolarization that begins in the working myocardium, outside of the His-Purkinje system) and hence indistinguishable QRS complexes we have shown that there are often significant differences in QRS morphology between these two arrhythmia types. We believe that there are three main sources of these differences: (1) no AV dissociation in preexcited tachycardias, (2) obligatory basal to apical depolarization during preexcitation, and (3) lack of myocardial scar or fibrosis-related ECG features in preexcited SVT patients. Recent data support the notion that several of the classic morphologic criteria for VT are not related to VT per se (or to initial slow depolarization outside of the His-Purkinje system) but to the presence of organic heart disease (e.g., fibrosis, scars, and ventricle dilatation), as they are absent in idiopathic VT, yet present during supraventricular rhythm in heart failure patients with left bundle branch block (Jastrzebski, Kukla, Czarnecka, & Kawecka-Jaszcz, 2012b; Wijnmaalen et al., 2011). The same applies to preexcited VTs—as these also mostly occur in healthy hearts, and bear resemblance to a rare VT subtype only: an idiopathic annular VT. This is why VT-specific ECG criteria resulting mainly from the presence of a scar (qR in V_2–V_6, S-wave notch in V_1/aVR) or from grossly abnormal vector of depolarization (monophasic R in aVR, no RS in V_1–V_6) are very rare in preexcited SVT. In consequence, while a preexcited SVT can exhibit some VT-specific features, an organic heart disease based VT will usually have much more such features. Therefore, a method that makes a diagnosis on the basis of the concomitant presence of several such features (VT score ≥ 3) or on the presence of features truly very rare in preexcited QRS (Steurer algorithm) will be able to differentiate between preexcited SVT and VT.

5.1 | Ventricular tachycardia score

The VT score results indicate that a preexcited SVT bears some, albeit limited, resemblance to a VT. Preexcited SVT very often (74% of cases) exhibits one or two VT-like features. However, VT score of 3 is present in only <4% of preexcited SVTs and VT score ≥ 4 in none (Table 2). This is a significant difference that allows firm differentiation between most VTs and preexcited SVTs. This corroborates results of our prior VT score validation study, based on a 786 ECGs, where VT score misclassified only one WCT, indeed, a preexcited SVT as a VT (Jastrzebski et al., 2016). This misclassified SVT had VT score of 3 as the only one of 38 preexcited SVTs included in that study. This would point to 2.6% real-life preexcited SVTs that can be misclassified by the VT score and is quite similar to the results of the current study, which included almost 10 times more preexcited tracings, where 3.9% of preexcited SVTs were misclassified.

5.2 | Brugada algorithm

The first step of the Brugada algorithm (lack of RS criterion) is very specific for VT diagnosis, both in general cohort of patients (Jastrzebski et al., 2016), and as shown by the current results, also in patients with preexcited WCT. Of note, this criterion encompasses former the Marriott criterion of positive/negative QRS concordance and Coumel criterion of qR in the precordial leads (Marriott, 1970; Coumel et al., 1984). While negative concordance and qR are not observed during preexcitation, positive concordance is—slightly lowering specificity of this criterion. In contrast to the first step, the second step criterion (RS > 100 ms) is very nonspecific, fulfilled in every second preexcited tachycardia. In addition, the final step of this algorithm is rather nonspecific. The net result is a 31% specificity of the whole method. In other words, two out of the three preexcited tachycardias will be diagnosed by the Brugada algorithm as VT. In the original publication by Brugada et al. that introduced this popular algorithm, there is no information concerning inclusion or exclusion of patients with preexcited SVT (Brugada et al., 1991). Therefore, one might assume that this algorithm is universal, that is, tested on a general cohort of WCTs and suited for all patients, including preexcited SVT patients. Despite subsequently published opinions that Brugada algorithm might not be able to differentiate VT from preexcitation (Steurer et al., 1994; Vereckei & Miller, 2012), this algorithm and its criteria were never properly studied in this regard. The current study provides data which show that while Brugada algorithm as a whole is unable to differentiate preexcitation from ventricular ectopy, some of its criteria might be very useful.

5.3 | The aVR algorithm

The first three criteria of this algorithm being basically Marriott and Kindwall morphologic criteria applied to lead aVR instead of lead V_1 are relatively specific in the setting of preexcitation (specificity of 89%–96%). Especially, the first criterion, a monophasic R in aVR is seen only in 4 out of 100 preexcited SVTs. However, the final step of this algorithm (V_i/V_t criterion) being the inventive contribution of Vereckei, Duray, Szenasi, Altemose, & Miller (2007); to the field of WCT differentiation is incapable of differentiating between preexcited SVT and VT; it is fulfilled in almost every preexcited QRS due to the presence of initial slow depolarization known as the delta wave. Consequently, the whole algorithm misclassifies 89% of preexcited

SVTs. The authors of this algorithm have already suggested that this algorithm might not be capable of VT/preexcited WCT differentiation (Vereckei et al., 2008), and later even revealed they grouped preexcited SVTs with VTs, considering diagnostic mistakes (e.g., preexcited sinus tachycardia diagnosed as VT) as correct answers, thus questionably increasing specificity and accuracy of the method (Jastrzebski & Kukla, 2012; Vereckei & Miller, 2012). Our data corroborate the opinion of Vereckei et al. (2008) that the whole aVR algorithm cannot differentiae preexcitation from ventricular ectopy and that only the monophasic R in aVR criterion (the first step of the aVR algorithm) is useful for this task .

5.4 | Steurer algorithm

This is the only algorithm designed specifically to deal with the problem of VT versus preexcited SVT differentiation (Antunes, Brugada, Steurer, Andries, & Brugada, 1994; Steurer et al., 1994). Our results confirm the very high specificity of both criteria and of the whole algorithm. Steurer et al. found it to be 100% specific while our results, based on a three times bigger cohort of preexcited SVT patients, point to a slightly lower specificity of 97.6%. The major limitation preventing the application of this algorithm is not its unquestionable high specificity in this specific subpopulation, but its sensitivity and overall accuracy in a general population. Importantly, in contrast to other WCT algorithms and the VT score method, this little-known algorithm was never validated on a general cohort of WCT patients. Steurer et al. (1994) assessed its performance only on a rather artificial group of patients consisting of 149 VTs (mainly postinfarction) and 118 preexcited SVTs, excluding the usual wide complex SVTs, that is, SVTs with functional or preexistent bundle branch block. In a sibling publication concerning this algorithm, coauthored by Brugada and Brugada, there is a suggestion that this algorithm should be used post main Brugada algorithm; that is after differentiation between VT versus SVT with aberration was already completed (Antunes et al., 1994). Such resulting seven-step method was also never validated on a real-life cohort of patients. It seems likely that the low sensitivity of the Steurer criteria would significantly impact on the overall accuracy of such approach.

6 | LIMITATIONS

Majority of analyzed ECGs were recorded during fast atrial pacing with maximal obtainable preexcitation. Most likely, such ECGs correspond in vast majority of cases with preexcitation that would be observed during bona fide preexcited SVT or antidromic atrioventricular reentrant tachycardia. However, some differences in QRS morphology cannot be excluded. Atrial pacing site was either in the high right atrium or proximal coronary sinus and some merging of the paced p wave with QRS was possible, similarly as during true preexcited SVT. Moreover, we believe that simultaneous recording of all 12 ECG leads helped to precisely delineate the beginning of the QRS.

All observers interpreting the ECGs knew that there were no true VTs included. This might have promoted bias in assessment of some criteria, especially in case of criteria that are dependent on ascertainment of QRS onset and offset.

7 | CONCLUSION

This is the first study that assesses the performance of various single ECG criteria and complex ECG-based methods for wide QRS complex tachycardia differentiation in patients with ventricular preexcitation dispelling the myth that preexcitation cannot be differentiated from ventricular ectopy.

Despite significant overlap in QRS morphology between preexcited and ectopic QRS complex, there are usually sufficient electrocardiographical differences to allow electrocardiographic differentiation. In contrast to other methods, VT score and Steurer algorithm do not overdiagnose VT in patients with preexcitation. Perhaps these two methods or selected single criteria that were found to be specific for VT should be preferred in patients more likely to have preexcitation.

ORCID


Marek Jastrzębski http://orcid.org/0000-0002-3318-6601

REFERENCES

Antunes, E., Brugada, J., Steurer, G., Andries, E., & Brugada, P. (1994). The differential diagnosis of a regular tachycardia with a wide QRS complex on the 12-lead ECG: Ventricular tachycardia, supraventricular tachycardia with aberrant intraventricular conduction, and supraventricular tachycardia with anterograde conduction over an accessory pathway. *Pacing and Clinical Electrophysiology*, *17*, 1515–1524.

Brugada, P., Brugada, J., Mont, L., Smeets, J., & Andries, E. W. (1991). A new approach to the differential diagnosis of a regular tachycardia with a wide QRS complex. *Circulation*, *83*, 1649–1659.

Coumel, P., Leclercq, J. F., Attuel, P., & Maisonblanche, P. (1984). The QRS morphology in post-myocardial infarction ventricular tachycardia. A study of 100 tracings compared with 70 cases of idiopathic ventricular tachycardia. *European Heart Journal*, *5*, 792–805.

Fijorek, K., Fijorek, D., Wisniowska, B., & Polak, S. (2011). BDTcomparator: A program for comparing binary classifiers. *Bioinformatics*, *27*, 3439–3440.

Griffith, M. J., Garratt, C. J., Mounsey, P., & Camm, A. J. (1994). Ventricular tachycardia as default diagnosis in broad complex tachycardia. *Lancet*, *343*, 386–388.

Jastrzebski, M., & Kukla, P. (2012). Limitations in the aVR algorithm should not lead to a redefinition of ventricular tachycardia. *European Pacing, Arrhythmias, and Cardiac Electrophysiology*, *14*, 1674–1675.

Jastrzębski, M., Kukla, P., & Czarnecka, D. (2017). Ventricular tachycardia score - A novel method for wide QRS complex tachycardia differentiation - Explained. *Journal of Electrocardiology*, https://doi.org/10.1016/j.jelectrocard.2017.04.003

Jastrzebski, M., Kukla, P., Czarnecka, D., & Kawecka-Jaszcz, K. (2012a). Comparison of five electrocardiographic methods for differentiation of wide QRS-complex tachycardias. *European Pacing, Arrhythmias, and Cardiac Electrophysiology*, *8*, 1165–1171.

Jastrzebski, M., Kukla, P., Czarnecka, D., & Kawecka-Jaszcz, K. (2012b). Specificity of the wide QRS complex tachycardia algorithms in recipients of cardiac resynchronization therapy. *Journal of Electrocardiology*, *45*, 319–326.

Jastrzebski, M., Sasaki, K., Kukla, P., Fijorek, K., Stec, S., & Czarnecka, D. (2016). The ventricular tachycardia score: A novel approach to electrocardiographic diagnosis of ventricular tachycardia. *European Pacing, Arrhythmias, and Cardiac Electrophysiology*, *18*, 578–584.

Kindwall, K. E., Brown, J., & Josephson, M. E. (1988). Electrocardiographic criteria for ventricular tachycardia in wide complex left bundle branch block morphology tachycardias. *American Journal of Cardiology*, *61*, 1279–1283.

Lau, E. W., Pathamanathan, R. K., Ng, G. A., Cooper, J., Skehan, J. D., & Griffith, M. J. (2000). The Bayesian approach improves the electrocardiographic diagnosis of broad complex tachycardia. *Pacing and Clinical Electrophysiology*, *23*, 1519–1526.

Marriott, H. J. (1970). Differential diagnosis of supraventricular and ventricular tachycardia. *Geriatrics*, *25*, 91–101.

Pava, L. F., Perafan, P., Badiel, M., Arango, J. J., Mont, L., Morillo, C. A., & Brugada, J. (2010). R-wave peak time at DII: A new criterion for differentiating between wide complex QRS tachycardias. *Heart Rhythm: the Official Journal of the Heart Rhythm Society*, *7*, 922–926.

Sandler, I. A., & Marriott, H. J. (1965). The differential morphology of anomalous ventricular complexes of RBBB-type in lead V1: Ventricular ectopy versus aberration. *Circulation*, *31*, 551–556.

Steurer, G., Gursoy, S., Frey, B., Simonis, F., Andries, E., Kuck, K., & Brugada, P. (1994). The differential diagnosis on the electrocardiogram between ventricular tachycardia and preexcited tachycardia. *Clinical Cardiology*, *17*, 306–308.

Swanick, E. J., LaCamera, F. Jr, & Marriott, H. J. (1972). Morphologic features of right ventricular ectopic beats. *American Journal of Cardiology*, *30*, 888–891.

Vereckei, A., Duray, G., Szenasi, G., Altemose, G. T., & Miller, J. M. (2007). Application of a new algorithm in the differential diagnosis of wide QRS complex tachycardia. *European Heart Journal*, *28*, 589–600.

Vereckei, A., Duray, G., Szenasi, G., Altemose, G. T., & Miller, J. M. (2008). New algorithm using only lead aVR for differential diagnosis of wide QRS complex tachycardia. *Heart Rhythm: the Official Journal of the Heart Rhythm Society*, *5*, 89–98.

Vereckei, A., & Miller, J. M. (2012). Classification of pre-excited tachycardias by electrocardiographic methods for differentiation of wide QRS-complex tachycardias. *European Pacing, Arrhythmias, and Cardiac Electrophysiology*, *14*, 1674–1675.

Wijnmaalen, A. P., Stevenson, W. G., Schalij, M. J., Field, M. E., Stephenson, K., Tedrow, U. B., … Zeppenfeld, K. (2011). ECG Identification of Scar-Related Ventricular Tachycardia With a Left Bundle-Branch Block Configuration. *Circulation. Arrhythmia and Electrophysiology*, *4*, 486–493.

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